

The weather map, based on the 7 p. m. observations of that date, shows an area of low pressure central over southern Minnesota, the lowest sea-level pressures reported being 29.60 inches, at Minneapolis and Moorhead. To the eastward in the St. Lawrence Valley there was a weak area of high pressure, 30.16 inches at Alpena. At Moorhead, Minneapolis, and Dubuque the wind was light southeast, the current temperatures being 74°, 78°, and 86°, respectively. At Duluth the wind was northeast, 20¹ miles, and the temperature was 50°. It will be seen from the foregoing that conditions were highly favorable for severe local squalls in the region south of Lake Superior.

The tornado originated a few miles north of the town of Roberts, which is slightly southwest of the center of St. Croix County, Wis., and traveled approximately northeast, passing close to the junction of Dunn and Polk Counties, and thence about east-northeast across southern Barron County to the vicinity of Chetek, where it was last reported.

Reports differ as to the exact time of the passage of this storm, but evidently it first was felt, near Roberts, about 7 p. m., and disappeared, near Chetek, about 9 p. m. As the length of the path was approximately 40 miles, the storm as a whole traveled only about 20 miles an hour.

The width of the path of great destruction varied from a few rods to two miles or more. In places along the path, particularly in western Barron County, destruction occurred over an area approximately 15 miles wide. It seems evident that in the wider portions of the storm's path much of the damage was caused by a severe thunder squall, rather than by the tornado proper. The characteristic funnel-shaped tornado cloud was reported from many points, but there were several observers in different localities who failed to see it.

The greatest destruction occurred in northeastern St. Croix County and in southern Barron County, but there was considerable damage in northwestern Dunn County and in southeastern Polk County. The property loss was extremely heavy in Forest Township, St. Croix County, and probably nearly as heavy in Vance Creek Township, Barron County. The greater part of the storm track was through a thinly settled region; otherwise the damage would have been much greater.

Fatalities reported were as follows: One in Polk County, two in St. Croix County, and five in Barron County.

Approximately 100 houses and barns were destroyed, much live stock was killed by wind and lightning, and a wide extent of crops were injured, in many cases the loss being complete. More or less serious damage was reported from the towns of Arland, Chetek, Deer Park, Emerald, Erin, Forest, Hammond, and Vance Creek.

It is believed a conservative estimate of the property loss is \$500,000, probably three-fourths of which represents buildings destroyed, mostly on farms, and the remainder loss of crops, live stock, etc.

Tornado near Antigo.—At 2:30 p. m., June 16, 1922, a tornado passed from southwest to northeast about 2 miles west of Antigo, Langlade County, Wis., destroying about 10 farm buildings, many trees, and some live stock. No fatalities nor personal injuries were reported. The loss of buildings, live stock, etc., is conservatively estimated at \$50,000. The damage to crops was not great. This was a real tornado, although a very brief one, the funnel-shaped cloud being reported by all observers. The width of the path of great destruction was 10 to 20

rods and its length about 1½ miles. Extensive inquiry fails to find any trace of this storm at any other point. The following note is from a report by the postmaster at Bryant, Wis., about 8 miles northeast of Antigo:

The tornadic part of the storm was west of Antigo, although it blew hard here at Bryant without doing any damage of consequence. The tornado looked like it reached up about 1,000 feet or more in the air, with a width of about 10 to 20 rods on the ground decreasing to a narrow strip higher up, and revolving with great velocity.

THUNDERSQUALLS IN WISCONSIN, JUNE 9-10, 1922.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis.]

During the night of June 9, 1922 and during the day following, destructive local thundersqualls swept over many counties in western, southern, and eastern Wisconsin, causing a property loss estimated at over \$500,000. No fatalities were reported and only a few persons injured. Of the property loss probably one half was from the destruction of buildings, mostly on farms, and the remainder from loss of crops, live stock, etc.

Near the town of Eagle Point, Chippewa County, the storm exhibited some of the characteristics of a tornado; at all other points evidently only straight-line winds were involved. No one reported a funnel-shaped cloud. However, in most sections the destruction occurred during the night and had there been such a cloud it would not have been visible.

On the morning of June 9, 1922, an extensive barometric depression covered the Rocky Mountain and plateau regions, with the lowest pressure, 29.56 inches, sea level, at Salt Lake City. The evening map of the same day showed the center of low pressure, 29.42 inches, at Denver, and a development of the low-pressure area eastward across the Lake region to Ontario. At this time, 7 p. m., there was a sharp temperature gradient over Wisconsin, the current readings being: At Madison, 80°; at Dubuque, 82°; at Milwaukee and Minneapolis, 70°; at Marquette, 50°, and at Duluth, 44°. On the morning of June 10 there was an elongated area of low pressure extending from Arizona to Ontario, with the lowest pressure, 29.54 inches, at Omaha. By the morning of the 11th the area of low pressure had passed into the St. Lawrence Valley and a moderate high-pressure area had overspread the entire West.

Destructive winds were first reported about 11 p. m., June 9, in Dunn County, in northwestern Wisconsin. From that point they spread to the east and southeast and did not subside in some eastern counties until midnight the 10th. Most of the damage occurred between midnight of the 9th and daybreak of the 10th. However, the destruction in Sauk County occurred about 10 a. m.; that in Dane County about 11 a. m., that in Waupaca County not until 3 p. m.

The property loss in Chippewa and Dunn Counties was extremely heavy, the estimate of one reporter being \$300,000 for Chippewa County alone. The damage was nearly as great in Jackson, Sauk, Green Lake, and Fond du Lac Counties, and there was serious loss in Eau Claire, Dane, Jefferson, Waupaca, Winnebago, and Calumet Counties. Following is a description of the storm at Eagle Point, Chippewa County, as given by Mr. C. L. Richardson of Chippewa Falls:

The storm apparently had none of the features of the western tornado, but rather resembled the thunderstorm, marked only by unusual intensity of the wind. It advanced broadside across the country,

¹ Doubtless due to the local topography at the Weather Bureau station.—Edron.

sweeping most of Chippewa County. Friday was warm, but cooler than the preceding or following days; air, damp. About 11:30 p. m. the wind blew from the northeast with a velocity of 15 to 20 miles an hour. The clouds seemed blackest in the northwest, but the lightning came up from the southwest. The wind backed from northeast to southwest from 11:30 p. m. to 11:50 p. m. At that time I estimated from 100 to 150 flashes of lightning per minute. The wind increased, veering to the west and northwest, and rose to 40 miles or more I should judge, with pauses and more violent blasts. Three, or perhaps four of the most violent gusts of wind, lasting one to two minutes each, occurred just before midnight, the worst about 11:57 p. m. This prostrated trees and buildings, laying them east, about 5° to 8° south. Two minutes later, and lasting about two minutes, the wind blew violently from the southeast, directly reversed, and then veered rapidly south, southwest, and west, where it remained. Rain fell heavily all of this time, seeming to reach a climax about 12:05 a. m. The lightning was continuous, but the thunder was high and distant. Only two or three fires were caused by lightning. The hail was unusual, varying from small stones to cases, seemingly verified, of masses of ice, square, triangular and jagged, as large as a man's fist. One mass of ice is said to have been a foot square and to have weighed between 20 and 30 pounds. I have some woods traversed by three "windfalls" 2 to 10 rods wide. Some of the trees are twisted with the watch hands. On the north side the trees fell south; otherwise they are east-southeast.

CONCUSSIONS FROM NAVAL GUNFIRING FELT AT LOS ANGELES.

RAYMOND A. NELSON, Meteorologist.

[Los Angeles Chamber of Commerce, Apr. 25, 1922.]

The United States Navy seems to have chosen southern California waters for regular battle practice of the Pacific Fleet, the ships running from Los Angeles Harbor, their home, to a point 20 to 30 miles from the coast or off Santa Catalina and San Clemente Islands. This gives the ships a position 30 to 40 miles south to southwest of Los Angeles.

Frequently when the ships are at practice, concussions are felt in Los Angeles but with varying intensities. When the ships are firing, it is common to notice faint vibrations of windows and doors, but sometimes the vibrations reach such proportions that nearly everyone immediately says "earthquakes." Shocks of "earthquake" proportions took place on the evenings of January 17 and March 23, 1922, during night target practice. Papers over the country gave out wild reports following the first date; college professors in other parts of the State said it was impossible for the shocks to be felt as far as Los Angeles and that they were earthquakes. Seismographs throughout the State of California recorded no movements on that date and the MONTHLY WEATHER REVIEW for January reports

that earthquakes were felt in California from the 26th to the 31st only and these mostly in the northern part of the State except for shocks felt in Imperial Valley where earthquakes are frequent.

I have studied earthquakes somewhat and made a complete record of the shocks that occurred in southern California during the summer of 1920 and at the instant of the shock of January 17 I timed it and tried to get a duration and direction. Nothing was moving, such as chandeliers, pictures, or other hanging articles, and yet the windows and doors rattled as loud as during an earthquake of intensity 6 or 7. Sixty seconds passed and another shock, then another, and at regular intervals for half an hour or so. There was absolutely no floor movement or other vibration except for the rattle of windows. This same condition occurred again on the evening of March 23 and at the same time. The reason for these great atmospheric waves affecting Los Angeles seems to be a question of pressure distribution and the meteorological elements resulting.

It is a well-known fact that sound coming from some point may be heard more distinctly at certain times than at others. The distance at which the sound may be heard is also variable. The wind direction plays a most important part in this, in that if the sound-emitting body is in the direction from which the wind is blowing, the sound will be carried a greater distance. Sound waves traveling against the wind will be retarded.

The weather conditions during the evenings of January 17 and March 23 were practically the same. At both times an area of low pressure was central over Nevada and Utah, with a rather weak high-pressure area off the north Pacific coast. Under these conditions southern California would experience southwest winds with unsettled weather and considerable cloudiness. These normal conditions were taking place on the dates in question. The southwest wind was not only a surface wind but in effect at an elevation of over 6,000 feet. The sky was cloudy and these atmospheric waves were traveling with the wind as the ships were to the southwest of the city. The flashes were the result of star shells used by the ships to locate the "enemy." Under normal pressure conditions the valley in which Los Angeles is situated would be under the influence of the regular land and sea breeze—the sea breeze (southwest) during the day and the land breeze (northeast) at night. Had the low-pressure area over Nevada not been so strong and the regular northeast land breeze blowing, the shocks or concussions would have been very faint had they been noticed at all.